AMENDMENTS TO THE SPECIFICATION
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Reference Number	Description
E	Ellipse for Root Form
E_{MI}	Ellipse Minor Diameter
E_{MJ}	Ellipse Major Diameter
T_{th}	Thread Taper
T_C	Crest Taper

Description of Drill Pipe with Tool Joints

Figure 1 illustrates lower and upper drill pipes 2, 2′ connected together by means of a tool joint 4 according to the invention. The drill pipes 2, 2′ have upset portions 3, 3′ which have thicker wall thickness for welds 6, 6' at the ends of the drill pipe to the ends of the tool joint 4. The Outer Diameter of the pipes 3, 3′ is indicated as P_{OD} while the pipe inner diameter, for almost all of its 30' length, is indicated as P_{ID}. The inner diameter of the ends of the pipe 3, 3′ at the upset portion is indicated as PU_{ID} which approximately matches the inner diameter ~~TJ_{ID}~~ $\underline{TJ_{ID1}}$ of the weld ends of the Tool Joint. While the outer diameter of the tool joint TJ_{OD} is substantially constant along the length of the tool joint L_{TJ}, the inner diameter of the tool joint narrows from TJ_{ID1}, at the weld ends of the joint to TJ_{ID2} for the section adjacent the threads of the pin 10 and box 12. According to the invention, TJ_{ID2} may be 1/8 inch (or more) smaller in diameter than TJ_{ID1}, in order to provide thicker wall thickness for the threaded section of the tool joint 4. It has been found that while too small an inside diameter for the tool joint may decrease allowable fluid flow rates during drilling operations, a small decrease of 1/8 inch or 1/4 inch inside diameter over a short length can be tolerated while providing significant enhancement to the torque strength of the joint. It is preferred that the length of the tool joint where TJ_{ID2} applies be not greater than about 2/3 of the total tool joint length, $\underline{\text{LTJ}}$.

Figure 2 illustrates the double shoulder tool joint fully made up. According to a preferred embodiment of the invention, the pin nose cross sectional area CS_{PN} is at least fifty

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secondary shoulders and ultimately produces a further increase in torque capacity of the joint. Furthermore, the internal threads 20 and external threads 18 should have a stab flank 34 that makes an angle Θ_S with the fundamental triangle 48 from about 35 to about 42 degrees and a load flank angle Θ_P between about 25 and about 34 degrees. Preferably the stab flank angle Θ_S is about 40 degrees and the load flank angle Θ_P is about 30 degrees.

The thread form of Figure 3 is also characterized by crests 42 with a transition shape 44 between a load flank 36 and a crest 42. The transition shape 44 is characterized as a radius that is less than or equal to 0.012 inch thereby providing a large load flank 36. A transition shape 46 between the stab flank 34 and the crest 42 is equal to or greater than about .073 inch radius thereby reducing the thread crest width and enabling a gradual entry of the mating thread during stab-in and make up. The roots 40 of the thread form according to the invention are formed in the shape of an ellipse E having a major axis of E_{MJ} and a minor axis E_{MI}. The root shape 40 is selected to provide a smooth transition with the stab flank 34 and pressure flank 36. The ellipse shape E produces a stress concentration factor less than that of a 0.038 inch root radius.

As can be seen in the enlargement of the thread crest 42 in Figure 4, the top of the crest 42 slopes with a crest taper T_C at an angle opposite from that of the thread taper T_{th}. Preferably crest taper is about 1 degree. The description above of prior art thread forms by reference to Figures 5 and 6A, 6B and 6C shows that a crest 41 crest taper that is angled approximately the same as the thread taper T_{th} can produce wedging of the threads. Conventional parts of the thread forms are labeled: thread root 39, stab flank 33, load flank 35, transition from ~~laod~~ load flank to crest 43, and transition from crest to stab flank 45. A thread form with a crest taper T_C at an angle opposite from that of the thread taper T_{th} allows the pin to be more easily stabbed into the box. Figures 7A, 7B and 7C illustrates the

advantage, where Figure 7A is a side view of a pin 10 being stabbed into a box 12 of the tool joint and